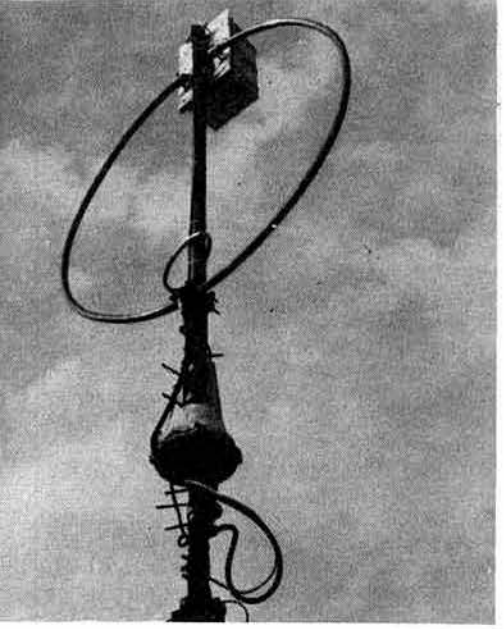


A CLOSE VIEW OF THE LOOP IN THE DEFINITIVE INSTALLATION. NOTE THE SMALL COAX FEEDING LOOP AND THE SHIELDED WIRE FIXED ALONG THE PLASTIC MAST FOR FEEDING THE TUNING MOTOR.

PLUMBING NORMALLY IS CONFINED TO MICROWAVES. NOW YOU NEED TO BEND 22MM COPPER TUBE FOR THE HF BANDS

ELECTRICALLY TUNABLE HF LOOP

BY ROBERTO CRAIGHERO I1ARZ

Robert Craighero, born in 1929, was interested in radio since he was a high school student in the immediate post-war period. In 1949 he started his merchant navy career, obtaining his ship's master certificate in 1955. During that period he operated occasionally as "mobile marine". In 1959 he was licencsed as 11ARZ and from that year his radio amateur activity has been regular, having left the sea for a shore job in the shipping field. He is more inclined to experimentation and homebrewing. His interest in radio is still as high as in the early days. Since 1971 he has beeen a member of the managerial staff of one of the major state owned shipping companies in Italy.

The compact HF transmitting loop antenna – and the active receiving loop – are now widely used in professional and military communications but still only rarely by radio amateurs. This is despite many articles (Ref 1-8) and even a booklet (9) on this interesting form of antenna. I began experimenting with small transmitting loops in 1985 and can confirm that they offer useful advantages to those amateurs unable to erect high dipoles or beam arrays. In this article I present the experience of myself and others, including a detailed description of the electrical and mechanical aspects of a loop antenna with a diameter of one metre, tunable over the range 14 to 29MHz.

HISTORY

Although compact loop antennas have been used for many years for reception, particularly in connection with direction-finding, the first significant attempt to overcome the transmission problem of their very low radiation resistance, typically well under one-ohm, appears to have been the octagonal loop with 5ft sides developed at the US Army Limited War Laboratory for use in the jungles of south-east Asia. This was described in *Electronics* (21 August 1967) and first brought to the notice of radio amateurs in the November 1967 issue of the *RSGB Bulletin (Technical Topics)*. In *QST* (March 1968) Lewis McCoy, W1ICP of ARRL described his attempt to duplicate this design but reported only modest success, possibly due to the ohmic resistance of the plumber's connectors used with the straight tubing. The original transportable US Army loop used 0·5in diameter tubing and a low-loss capacitive matching/tuning network, though it was recognised that it would be advantageous to reduce RF ohmic losses still further by increasing the surface area of the tubing by the use of 3, 4 or even 6-in diameter tubing!

The next few years saw the publication in the amateur-radio journals of various ideas including that of "Spenny" (G6NA) of using "0·5in" coaxial cable to form a 1·8MHz loop, with an overall efficiency of about 8% at 4MHz. In *QST* (November 1968) W20ZH described a fixed-frequency 3·9MHz "Mobiloop" using coaxial cable for a loop tuned to resonance by a high-voltage capacitor formed from a 13ft 7in length of 300-ohm tubular television twin-lead.

The 1970s and 1980s have seen the development of professional single and multiple-turn transmitting loops for such applications as low-profile HF embassy and marine installations, incorporating remote tuning. In 1983, DL2FA presented in *cq-DL* a comprehensive review of matching networks for transmitting loops including the use of a second inductive coupling loop, a technique also successfully used by a Swedish amateur for a three-turn, silver-plated loop for marine use (IERE Conference Proceedings No 50 reported in *TT*, September 1981). In 1985, Ted Hart, W5QJR published a useful booklet on the principles and practice of transmitting loop antennas.

GENERAL COMMENTS ON SHORT LOOP ANTENNAS

It may seem strange that an antenna capable of working efficiently at ground level should be so little used by amateurs. However, it must be recognised that good efficiency can be achieved only by taking into account the requirement that the loop should exhibit extremely low RF ohmic resistance. Additionally its high-Q characteristic results in a narrow effective bandwidth, requiring accurate retuning for even a small change in frequency; this can be overcome by the use of complex and expensive automatic tuning systems or, more realistically for amateurs, by remote control of the tuning capacitor forming part of the loop. Another disadvantage is that even on low-power, there will be very high RF voltage across the tuning capacitor, resulting in the need for either a high-cost vacuum capacitor or a good-quality, wide-spaced transmitting capacitor.

Against these disadvantages should be set the fact that a well-constructed loop at ground level can have a radiation efficiency close to that of a dipole antenna a half-wave above ground, and significantly better than a dipole less than a half-wave above ground. Furthermore, the short loop utilises the near-field magnetic component of the electromagnetic wave resulting in much less absorption in nearby objects: this means that a short loop can be

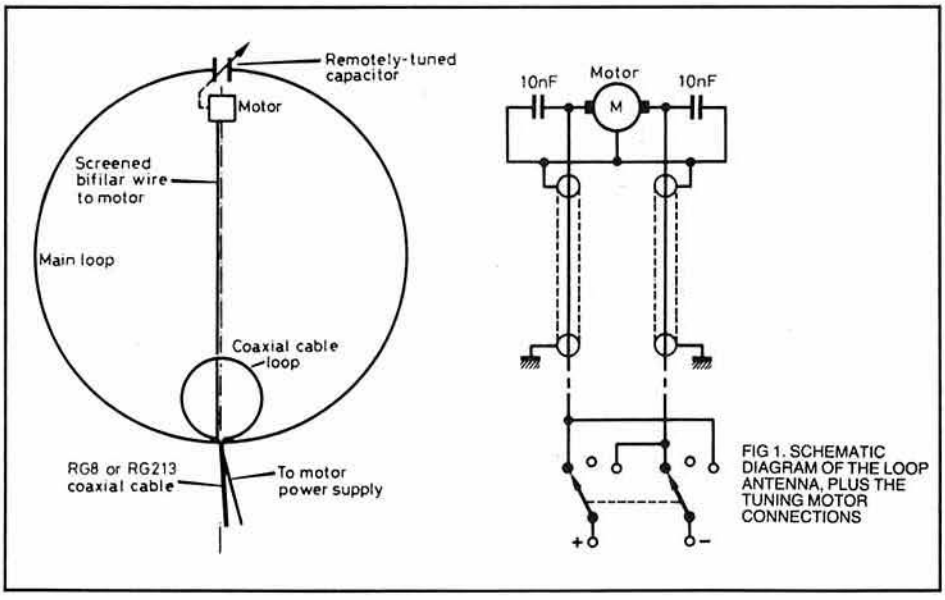


FIG 1. SCHEMATIC DIAGRAM OF THE LOOP ANTENNA, PLUS THE TUNING MOTOR CONNECTIONS

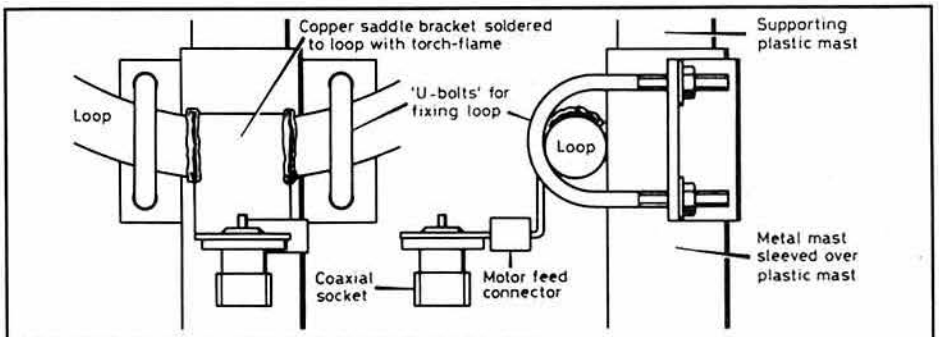


FIG 2. DETAILS OF THE BOTTOM OF THE LOOP – FROM THE FRONT.

used successfully indoors or on a balcony. For reception a 'magnetic' antenna is virtually immune to the electric component of nearby interference sources. The reduction of man-made noise is particularly important on the lower-frequency bands, and is further enhanced by the directional properties of a rotatable loop. The loop can work effectively without an artificial ground plane.

The high-Q characteristics of a low-loss loop also means that it forms an excellent filter in front of a receiver, reducing splatter and cross-modulation from strong signals. On transmission, these filtering properties dramatically reduce harmonic radiation and hence some forms of TVI and BCI.

BASICS

To achieve good radiation efficiency in a small transmitting loop it is essential to minimise the ratio of RF ohmic losses to radiation resistance. In a small resonant loop the RF ohmic losses are made up of the resistance of the loop and that of the tuning capacitor (which will have much lower resistive loss than a loading coil). The tendency of HF current to flow only along the surface of a conductor ('skin effect') means that large diameter continous copper tubing (or even silver-plated copper) should be used to achieve a maximum high-conductivity surface area.

Provided that the circumference of a loop is between 0·125λ and 0·25λ, it can be tuned to resonance by series capacitance; if the loop is longer than 0·25λ it will lose its predominant "magnetic" characteristic and become an "electric" antenna of the quad or delta type but, unless approaching 1λ in circumference, will still have relatively low radiation resistance.

The radiation resistance of a small loop is governed by the total area enclosed and is a maximum for circular loop. It is possible to build a transmitting loop antenna with a circumference less than 0·125λ but in these circumstances the bandwidth becomes so small that it becomes practically impossible to tune the loop accurately enough. It is thus advisable to restrict the operating range of a transmitting loop to a ratio of 1:2, that is to say 3·5 to 7, 7 to 14, or 14 to 28MHz. Extending the tuning range will tend to result in a rapid falling off in efficiency. The most convenient solution for complete HF coverage is to use two loops; one for the higher frequency bands (14, 18, 21, 24 and 28MHz), the other for 3·5 and 7MHz or 7 and 10·1MHz. For 1·8MHz it is advisable to use a loop designed for this band, or for 1·8 and 3·5MHz.

A 14 TO 29MHz LOOP

The main physical characteristics of this antenna are:

Dimensions: Circular loop, 1m diameter made from copper pipe of 22mm OD. Circumference 3·14m.

Capacitor: Split-stator or 'butterfly' type, about 120pF per section. Minimum capacitance (for 28MHz) 16pF. A single-section capacitor can be used provided that it is of high quality with an effective, low-resistance connection to the rotary plates. (It is possible to reduce such losses by soldering a large flexible copper braid between the rotor shaft and frame. Half the above capacitances for a single section capacitor, viz about 60pF maximum and not more than 8pF minimum.) CapCo produce a suitable capacitor for their commercial pattern of the loop antenna.

Feed: Inductive coupling with a small loop made from co-axial cable.

Maximum power: This is governed primarily by the spacing of the capacitor vanes. Suggested rating 100W maximum.

Tuning method: Remote control of capacitor by means of electric DC motor and reduction gear. Rotation speed not faster than one turn per minute.

The electrical characteristics, calculated from the formulae given by W5QJR in *QST* (June 1986), are ▶

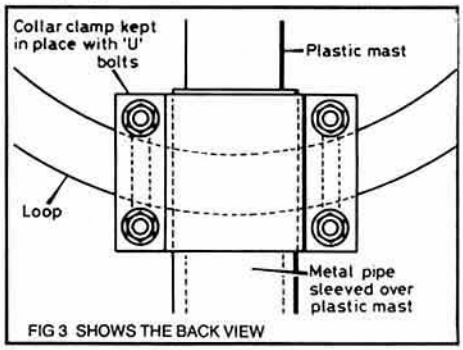
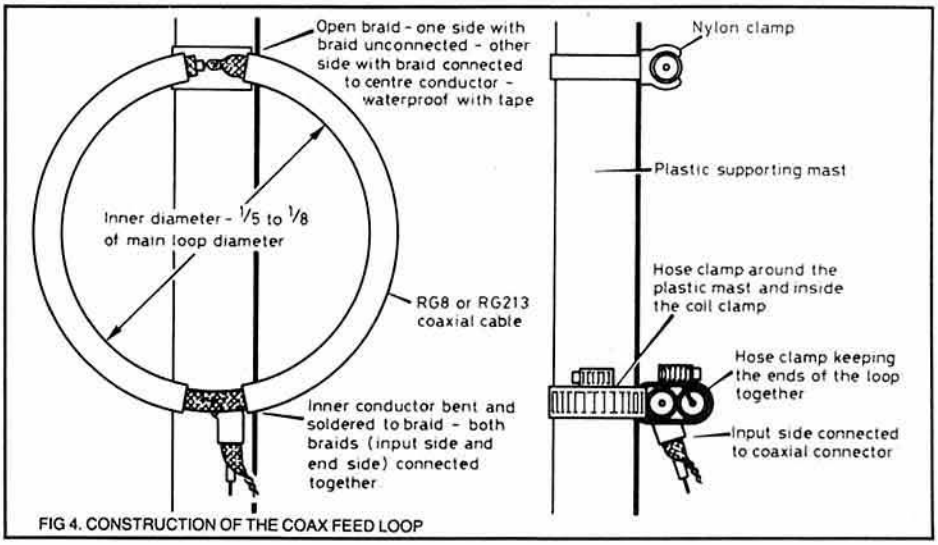


FIG 3 SHOWS THE BACK VIEW

TABLE 1 – ELECTRICAL CHARACTERISTICS OF A TRANSMITTING LOOP ANTENNA, 1m in diameter, made from 22mm copper tubing (calculated)

	14MHz	21MHz	28MHz
Radiation resistance, ohms	0·09	0·46	1·68
Conductor losses, ohms	0·04	0·05	0·06
Efficiency (%)	67·3	89·5	93·3
Loop inductance, HH	2·4	2·4	2·4
Inductive reactance, ohms	214	321	443
Q factor	789	311	127
Theoretical bandwidth, kHz	17·7	67·5	228
Voltage across tuning capacitor (100W), kV	4·1	3·1	2·3
Tuning capacitance, pF	53	23	12


Open braid - one side with braid unconnected - other side with braid connected to centre conductor - waterproof with tape
Nylon clamp
Plastic supporting mast
Inner diameter - 1/5 to 1/8 of main loop diameter
RG8 or RG213 coaxial cable
Hose clamp around the plastic mast and inside the coil clamp
Hose clamp keeping the ends of the loop together
Inner conductor bent and soldered to braid - both braids (input side and end side) connected together
Input side connected to coaxial connector
FIG 4. CONSTRUCTION OF THE COAX FEED LOOP

COMPUTER BASIC PROGRAM FOR LOOP CALCULATIONS

```
 5 CLS
10 PRINT "CALCULATION OF MAIN PARAMETERS
   OF A COPPER TUBING"
20 PRINT CIRCULAR SHAPED SHORT LOOP ANTENNA"
30 PRINT
40 PRINT
50 PRINT "Conductor Length              METERS:";: INPUT SS
60 S=SS*3·281
70 PRINT
80 PRINT "Conductor Diameter    MILLIMETERS:";: INPUT DD
90 D=DD*.03937
100 PRINT
110 PRINT "Frequency                      MHz:";: INPUT F
120 PRINT
130 PRINT "Power                         WATT:";: INPUT P
140 PRINT
150 CLS
160 A=7·900001E-02*S^2
170 PRINT "LOOP AREA              SQ. METERS:";: B=A*·0929:
    PRINT B
180 PRINT
190 RR=3·38 *10^-8*F^4*Â2
200 PRINT "Radiation Resistance          OHMS:";RR
210 RL=9·96*10^-4*SQR(F)*(S/D)
220 PRINT "Conductor Loss                OHMS:";RL
230 E=RR/(RR+RL)*100
240 PRINT "Efficiency in percentage          %:";E
250 DB=LOG(E/100)/LOG(10)*10
260 PRINT "Efficiency in dB                 dB:";DB
270 L=1·9*10^-8*S*(7·353*LOG(96*S/3·1418/D)/LOG(10)-6·386)
280 PRINT "Loop Inductance           HENRY:";L
290 XL=2*3·1418*F*L*10^6
300 PRINT "Inductive Reactance           OHMS:";XL
310 Q=XL/(RR+RL)/2
320 PRINT "Quality Factor                   Q:";Q
330 DF=2*(RR+RL)/XL*F*1000
340 PRINT "Bandwidth                      KHz:";DF
360 VC=SQR (P*XL*Q)
365 PRINT "Capacitor Voltage           VOLTS:";VC
370 CT=1/(2*3·1418*F*XL)*10^6
380 PRINT "Tuning Capacitor               PFd:";CT
```

set out in Table 1. I inserted these formulae in a short Basic computer program which makes it possible to calculate quickly all main parameters for different sized loops, comparing the solutions and optimising the antenna. The Basic adopted is IBM PC but can be easily adapted to any basic computer. My program is set out. Factors have been incorporated for conversion from feet and inches to metric measures.

THE LOOP

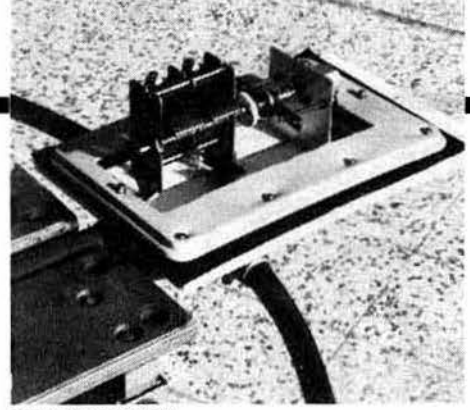
Copper pipe of 22mm OD is generally sold in straight lengths 5m long. In some cases it may be possible to obtain such pipe already coiled into circular shape; in such cases it is relatively easy to change this to the required diameter of 1m. The procedure I adopted with circular pipe was to make a chalk mark on the floor of the correct 1m diameter and then manually adjusting the pipe to this diameter; this requires two people, one keeping the pipe on the floor and the second slowly enlarging its diameter.

If you are unable to obtain a coiled pipe, it is possible to bend a straight pipe around a circular object of correct size; for example a round table or a large truck tyre. Before starting to bend the pipe, this should be filled with dry sand and the ends sealed. Sand must be pressed firmly inside while continously shaking the pipe. This prevents buckling of the pipe during bending or the formation of sharp bends. An alternative would be to find a workshop with a pipe bending machine, but this may be difficult to locate and would be more expensive.

Both ends of the loop must be cut longitudinally along the vertical diameter of the pipe for about 5cm, then cutting one half away. The remaining half is flattened to form strip that can later be inserted through the insulated board used to support the tuning capacitor and connected to the stator plates. In this way only one joint will be necessary for each stator, reducing the soldering losses. At the bottom of the loop, opposite the tuning capacitor, a small copper bracket should be soldered to the loop. On this bracket will be fixed the coaxial connector and the connector for the twin lead for powering the tuning motor. The bracket should be soldered to the loop with a torch-flame solder to ensure good electrical contact.

THE SUPPORTING MAST

Where a loop is to be used outside the house, it is imperative to provide a supporting mast across the loop; otherwise there is the risk that high winds will deform or break the loop. This can happen for two main reasons: the combined weight of the motor, tuning capacitor, plastic board and watertight cover is considerable; additionally 22mm copper tubing is not sufficiently strong to remain rigid in the presence of high dynamic stress unless supported. A thick PVC pipe of about 40-50mm diameter can be used for this support. Alternatively a glass fibre tube (lighter but more expensive) or a wooden mast waterproofed with plastic compound may be used. The length of this mast should be about1·50m, with about 20cm used at the top for fixing the plastic board carrying the tuning capacitor; the remaining length is used at the base for fixing the loop to a rotor or another short mast. For obvious reasons, never use a metallic pipe across the loop but a short piece of metallic pipe should be inserted at the base over the plastic pipe in order to have the loop grounded at the centre point where the loop



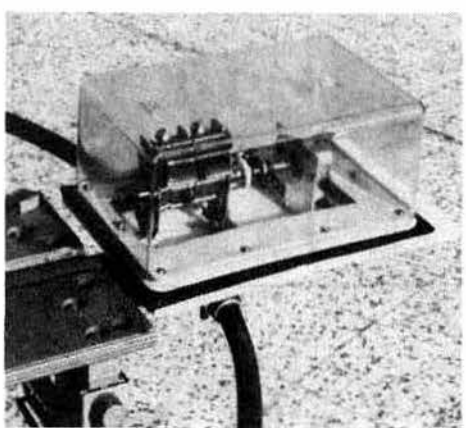
THE TUNING BOARD.

itself is kept against the supporting mast.

To fix the loop to the mast, I used at the base two U-bolts intended for fixing television antennas. In the top part, the loop ends are kept in place by means of two collar-clamps taken from cross joints in cast aluminium as normally used to connect the boom of television antennas to the mast. These clamps are connected with nuts and bolts (stainless steel) to the back of the plastic board supporting the capacitor. The bolts should be of sufficient length to act as adjustable spacers in order to have the loop completely upright. The plastic supporting mast is fixed to the back of the board by means of two semicircular clamps with stainless steel nuts and bolts of sufficient length to reach the front side of the plastic board. The two copper strips of the loop must be bent at 90° and inserted in suitable cuts in the board to reach the stators of the capacitor on the front side of the board. The cuts should later be waterproofed with silicone compound.

TUNING BOARD AND COVER

The size of the tuning board depends upon the dimensions of the variable capacitor and motor. The best material for high-power operation is Teflon 10mm thick; alternatively Plexiglass of the same thickness. When calculating the size of the board, allow space for fixing the clamps of the loop and for a waterproof cover to protect the complete tuning unit. For protection, I used a plastic watertight box of the type used for food in a refrigerator. The original cover was cut in the centre with an opening just wide enough to permit the entry of the capacitor and motor. Between the surface of the supporting board and the cover, I inserted a layer of soft rubber to act as a seal. The cover was then fixed in place with several small stainless nuts and bolts, fastened tightly so that the seal was compressed between the board surface and cover to make it watertight. The plastic box can now be put against its cover, keeping it in place with a tight nylon lashing. Silicone compound should now be applied all round to ensure that there can be no ingress of moisture. To prevent gradual deterioration of the plastic box it is advisable to use white self-adhesive plastic sheet to protect it against ultraviolet radiation from the sun.



THE WATERPROOF COVER IN PLACE – NOTE THE SEAL AROUND THE BOX COVER

THE TUNING CAPACITOR

It is most important to use a very good quality transmitting-type variable capacitor; otherwise the efficiency of the antenna will be much reduced. Owing to the high Q of this antenna, the RF voltage across the capacitor is very high (directly proportional to the power). With 100W power, this voltage will be between 4 and 5kV; with 500W it can be as high as 28kV!

It is most advisable to use a split-stator (or "butteRFly") capacitor of about 120pF per section; this has the advantage of the two sections being connected in series and eliminates losses due to the rotor (pigtail) contact. Assuming the loop is intended for use with a transmitter power of not more than 100W, the spacing between the vanes should be at least 1·5/2mm (ie 0·75mm). The "surplus" market remains a good source of excellent transmitting-type split-stator capacitors and it is worth taking time to locate a source rather than attempt to use a cheap capacitor which will almost certainly result in reduced efficiency of the loop antenna.

THE TUNING MOTOR

The motor forms an important part of the system; it calls for a DC motor with a reduction gear capable of providing very fine control, with the capacitor shaft rotating at only about one turn per minute or even less. An optimum solution is to use a motor having a wide range of working voltage – for example 3 to 12V to provide slow rotation at the lowest voltage for accurate tuning but a faster rate when changing bands. Again, it is the surplus market that may provide such a motor. Should you be unable to find a motor incorporating a suitable reduction gear it is possible to use a receiver-type slow-motion tuning drive; for my antenna I used a Bulgin gear with a reduction drive ratio of 25:1. Unfortunately in this unit the 25:1 ratio operates only for a fraction of a turn of the control shaft and then reverts to a ratio of 5:1. It proved possible to overcome this problem by cutting very carefully a stop tooth on the main shaft. When the capacitor reaches the stop positions at 0° and 180° the Bulgin gear acts as a friction clutch, permitting the motor rotation to continue without unduly forcing the shaft. Without such an arrangement it is necessary to provide a microswitch system inverting the rotation sense or to use a variable capacitor that is designed to rotate through 360° without stops.

For the motor, I used a 'surplus' one made by Bühler of Germany; this is a well-made, solid unit with a high-quality reduction gear; however the reduction is only to about five turns per minute so I was obliged to use the Bulgin drive. It is possible to buy Bühler motors in the UK from John and Johnston Ltd, Franklin Suite, The Priory, Haywards Heath, West Sussex, RH16 3LS (telephone 0444-441057). If you are prepared to buy a new motor, I would suggest their model coded 1·61·013·310·6. This operates with DC voltages from 6 to 3 volts, has a maximum turning speed of 1·3 turns per minute and a minimum of 0·5 turns per minute. There is a similar 12V motor, coded 1·61·013·330·0, with similar turning rates which would also be ideal for this application.

CONSTRUCTION OF THE TUNING SYSTEM

Construction of the tuning system calls for great care and attention to detail, otherwise there is the risk of damaging the various components unless they are accurately aligned.

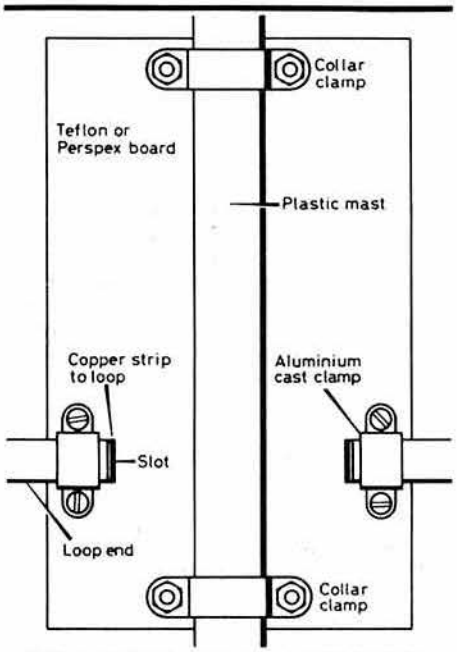
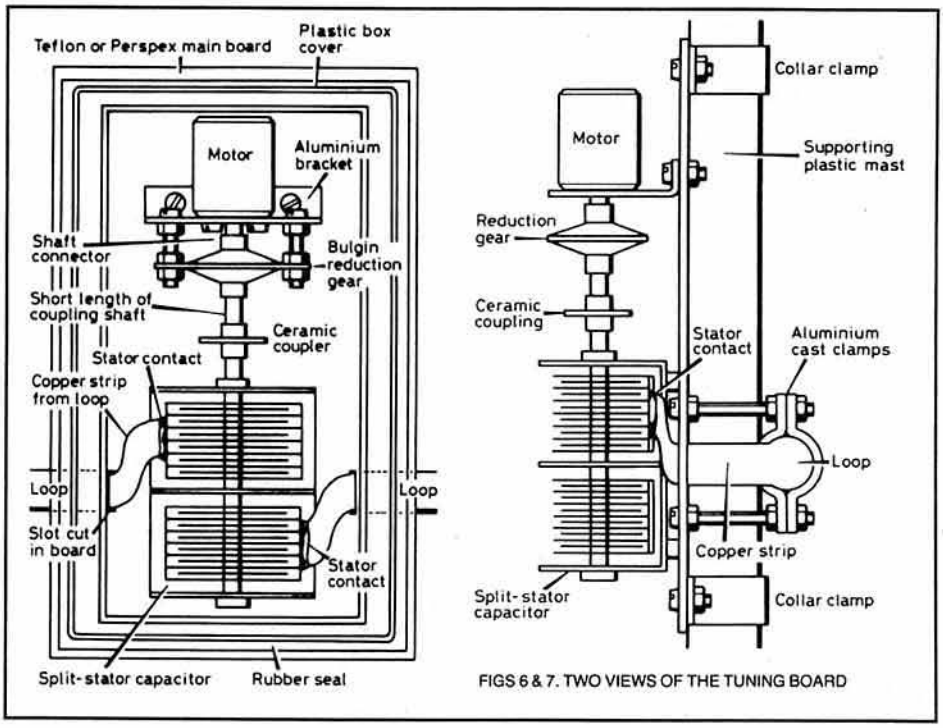


FIG 5. BACK VIEW OF THE TUNING BOARD SHOWING MOUNTINGS

After estimating the dimensions of the insulated supporting board as already described, keep also in mind the space required for the watertight cover, aluminium bracket for mounting the motor, and, if necessary, the external reduction gearing, together with the various couplings between the capacitor spindle and the motor. The first step is to mark with a pen the centre line of the board (ie major axis). Bolt the capacitor to the board, taking great care to ensure that the shaft is aligned with the centre line marked on the board. A split-stator capacitor must be placed with the respective stator contacts symmetrically in the vertical plane so that the copper strips coming from the back of the board on either side of the capacitor have the same length (one being bent upwards, the other downwards). With a "butteRFly" or conventional capacitor, the copper strips must be bent horizontally as both contacts are the same height. Once the capacitor has been bolted to the board, measure, with calipers or dividers, the exact distance of the board from the centre of the capacitor shaft. Transfer this dimension to the centre line of the vertical side of the L-shaped aluminium bracket to be used for supporting the motor and any external reduction gear. Now point drill a small hole just large enough to take the motor shaft. It is important that this operation is carried out carefully since it is vital to the accurate alignment of the system.

Once it has been determined that motor and capacitor shafts are in accurate alignment, the motor may be fixed permanently to the bracket, enlarging the preliminary hole and drilling holes for the motor-fixing bolts, but do not yet fix the bracket to the board.

The next step is to adapt the motor shaft to a shaft extension (as normally used for lengthening potentiometer shafts) taking care not to introduce any eccentricity. If your motor does not require external reduction-gear, you can insert the motor shaft into a ceramic coupler (circular shape with ceramic ring and flexible central bush), again making sure there is no eccentricity. The lower flange of the aluminium bracket can now be fixed to the board by means of two nuts and bolts. If the motor requires an external reduction gear, it is necessary, for a Bulgin drive, to drill two holes (4mm diameter) in the bracket, one in each side of the motor at the same distance as the mechanical connections of the gear and at the same level as the centre of the motor shaft. If the size of the motor is wider, it is necessary to join to the Bulgin gear two short strips of brass or aluminium so as to obtain an extension of the fixing points of the drive. Two long brass bolts (4mm diameter) should be inserted in the holes to hold the gear in place with the nuts. The Bulgin gear can now be fixed to the motor shaft, with the other side of the gear connected to the ceramic coupler by means of a very short piece of potentiometer-type shaft. Make a provisional check of the tuning system by temporarily connecting the power supply; ensure that everything is working smoothly without any forcing. The copper strips of the loop can now be soldered to the stator capacitor vanes. This requires the use of a large soldering iron, taking care that the best possible electrical contact is achieved.



FIGS 6 & 7. TWO VIEWS OF THE TUNING BOARD

MOTOR FEEDLINE

The feed line should consist of twin screened cable as normally used with high-fidelity audio amplifiers etc. The braid should be connected through a soldering lug to the aluminium bracket or to the motor casing. The motor must be bypassed for RF, using two 10nF ceramic capacitors connected to the braid. The cable is kept in place by means of nylon clamps along the supporting plastic mast. At the base of the loop the cable should be soldered to the connector on the small copper bracket, with the braid soldered to the bracket. From there to the operating position, normal electrical twin cable can be used. Some authors have suggested inserting the feed line inside the loop pipe but this reduces the efficiency of the antenna and their advice should not be followed. A small box containing the DC power supply and switch for reversing polarity of the supply can conveniently be placed on the operating desk.

COUPLING LOOP AND MATCHING PROCEDURE

A variety of methods for feeding the loop are available as outlined in *TT* (October 1986 p706) based on a survey by DL2FA. The most satisfactory method, however, is the use of a small, single-turn (Faraday) coupling loop formed from a length of coaxial cable (RG8 or RG213) with a diameter one-eighth of the main loop. In practice, the optimum diameter of the coupling loop will vary slightly from this figure and it may prove worthwhile to experiment with slightly different size loops in order to achieve maximum efficiency and lowest SWR over a wide frequency range; this is not difficult since it is easy to construct several coupling coils. In my case, the optimum diameter proved to be 18cm rather than the theoretical 12·5cm. The coil should have the braid open at top-centre; at this point one side is connected to the inner conductor of the coaxial cable. At the base of the loop, inner conductor and braid are connected together and jointed to the braid on the input side of the coil. To fasten the small loop I used a stainless hose clamp around the plastic mast, at 90° to another smaller hose clamp fixed across the joints of the braids at the base of the loop. This provides a very simple method of fixing, with quick release, and with the possibility of sliding the small loop up or down the mast to find the best SWR position. The upper opening should be protected with tape and, to avoid any subsequent movement of the coil, then fixed to the mast by means of nylon clamps mounted in the same way as for the hose clamps at the base. Final matching of the antenna has to be carried out after determining the final position of the installation. An SWR bridge is connected at the base of the loop close to the input coax connector. If your transmitter covers 18MHz make your adjustments on this band; othwerwise use 21MHz. Apply minimum power, just sufficient to deflect the SWR meter. After finding loop resonance, move the coupling coil up and down, or deform it slightly to check how the SWR varies. The coupling coil must be maintained in the same plane as the loop. After ▶

finding the lowest SWR, tighten the hose clamps and nylon clamps to keep the coil in position. Coax line and tuning motor power line must be kept vertical for about 1m or more from respective connectors at the base of the loop to avoid undesirable coupling with the loop itself and subsequent difficulty to achieve a proper matching. With my loop I obtained the following SWR measurements: 14MHz 1:1·3; 21MHz 1:1; 28MHz 1:1·6. Do not attempt to use an ATU.

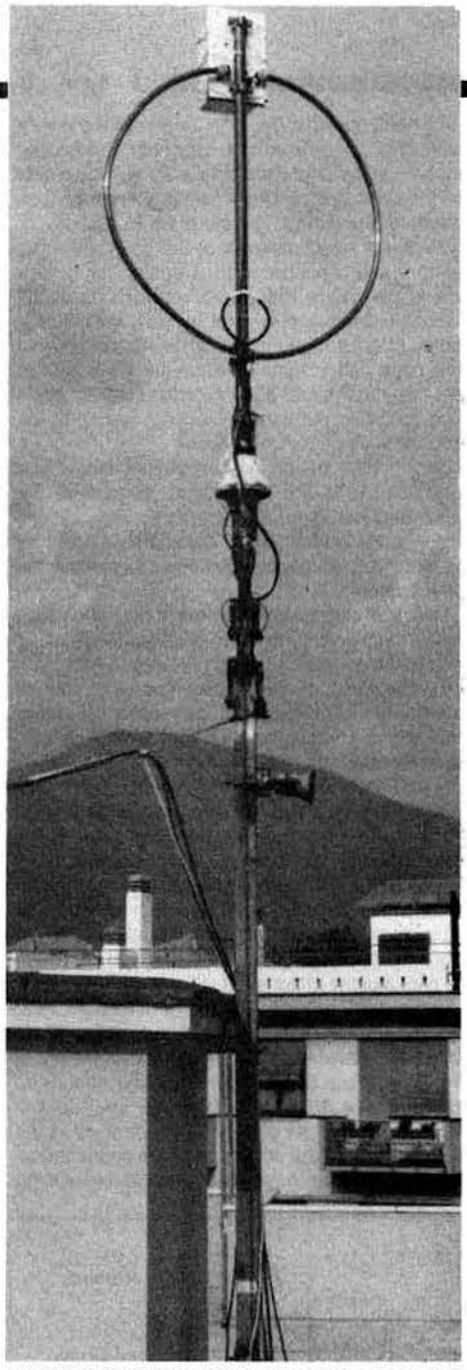
INSTALLING AND USING THE LOOP

The loop can conveniently be installed on a terrace or concrete floor or roof. One method is to use as a base or pedestal the type of plastic supports that can be filled with water or sand and often used for large sun umbrellas. Light nylon guys can be used to minimise the risk of the loop falling over in high winds. Remember that a transmitting loop operates effectively at heights of 1 to 1·5m above ground, and nothing will be gained by raising it any higher than say 2 or 3m at most. I tested my loop using a telescopic mast at heights up to 9m above ground but found little difference; normally I use it with the mast fully retracted to about 3m high. With a garden, the loop could be fixed directly to a short metallic mast driven into the ground. A small TV rotator could be used but this is not essential; maximum radiation is in the plane of the loop; minimum off the sides of the loop. Large metallic masses like fences, steelplates, pipes etc reduce the efficiency of the antenna if in proximity in the direction of the plane of the loop. The radiation is vertically polarized at all vertical angles making the loop suitable for DX, medium and short range contacts. The loop could be used in the horizontal plane, providing an omnidirectional radiation pattern, but in this case the loop must, as for a conventional horizontal element, be raised well above ground to obtain good efficiency at the low vertical angles of radiation needed for DX operation.

There is nothing particularly complicated about operating with a small loop antenna other than the need to tune it to resonance at the operating frequency. Load the transmitter in the normal way, then, looking at the SWR meter, tune carefully with the aid of the polarity reversing switch to the precise point where minimum reflected power is achieved. To avoid keeping the transmitter too long in the 'tune' position and to minimise the radiated interference to other band users, it is most advisable to tune initially in the 'receiving' mode; this will bring you close to the tuning point for transmission. The 'receiving-mode' procedure should always be used when changing bands.

USE OF AN INDOOR LOOP

A transmitting loop performs well indoors and there is a temptation to have the loop alongside the operating desk since it can then be tested with manual, rather than remote, tuning. I would advise against this unless you use only very low power. With full power, the RF voltages developed on the bare copper tubing are very high, with the risk of severe RF burns. There is also the potential hazard of prolonged exposure to strong magnetic RF fields, although the degree of risk remains controversial. It seems safer, if you or any of your family or neighbours beyond a party wall could be within a few feet of the loop, to use only QRP.



THE SHORT LOOP IN THE DEFINITIVE INSTALLATION. THE SUPPORTING MAST IS A TELESCOPIC MAST KEPT IN RETRACTED POSITION. THE HEIGHT OF THE ANTENNA FROM FLOOR IS ABOUT 3 METERS.

CONCLUSION AND FINAL COMMENTS

When I began experimenting with transmitting loops of small diameter in 1985, I was sceptical of the results likely to be achieved and was motivated by curiosity rather than conviction. It did not take long to discover that the loop antenna is very different from the many classical designs that I have tried in over 40 years of amateur activity. I began by collecting as much information as possible. I am now entirely convinced that the earlier claims are accurate and that the loop is a first-class, thoroughly practical antenna that should not be written off as either a compromise or emergency antenna. Its performance, provided the RF ohmic losses are kept very low, is outstanding. For several months I made comparative tests against a monoband half-wave dipole a half-wavelength above ground. I obtained better or the same results with the loop fixed at 1m height on top of a Black & Decker work-table on the roof terrace of my house. With a home-made QRP (2W) transceiver I was able to contact a number of US stations receiving reports better than S7. With my normal transceiver (maximum power 50W), results have been excellent, commonly resulting in S9 reports; similarly with stations in the Far East. From European stations, a report of S9 + 10dB is customary.

I would, however, stress that to achieve such results, it is essential to use components of high quality and to take care over the construction. Alternatively, it is possible to buy amateur-band antennas professionally constructed (10). Whichever approach you adopt, the transmitting loop has a unique fascination for anyone more used to conventional HF antennas. Try one and become hooked!

SELECTED REFERENCES AND FURTHER READING

The following are English-text references; useful additional information has also appeared in *cq-DL* (German text) and *Radio Rivista* (Italian text) etc.

(1) Kenneth H Patterson, *"Down-to-earth Army Antenna", Electronics*, August 21, 1967, pp111-113. See also letter from Richard Silberstein, *Electronics*, October 16, 1967.

(2) Pat Hawker, G3VA, *"Technical Topics" RSGB Bulletin/Radio Communication*; (a) *US Army Loop*, November 1967; (b) *WB2PWU's octagonal loop*, March 1968; (c) *W2OZH's low-cost balanced loop*, June 1971; (d) *TCI Model 629 professional transmitting loop*, December 1980; (e) *Sven Ramstroms SVI multi-turn transmitting loop*, September 1981; (f) *Professional "Miniloop"* by Antenna Research Associates, July 1984; (g) J. H. Dunlavy's *"Miniloop" patents*, June 1986; (h) *W5QJR's loop design and booklet together with DL2FA's survey of loop matching techniques*, October 1986.

(3) Lewis G McCoy, W1ICP *"The Army Loop in Ham Communications", QST*, March 1968.

(4) *'Spenny'* G6NA, *"Loop Aerials", Radio Communication*, September 1968.

(5) James Taylor, W2OZH *"The Mobiloop" QST*, November 1968.

(6) Joseph Boyer, *"Surprising Miniature Low Band Antenna", 73 Magazine*, August (Part 1), September (Part 2), 1975.

(7) Sven Ramstrom, *"HF Loop for Transmitting and Receiving"*, IERE Conference Proceedings No 50 *"Radio Receivers and Associated Systems"*, 1981, pp455-487.

(8) J. R. Killeen, G3KPV *"A compact HF antenna for portable or base operation" Radio Communications*, September 1983.

(9) Ted Hart, W5QJR *"Small high-efficiency antennas – alias the loop"*, 100-page booklet published by Ted Hart, W5QJR Antenna Products, PO Box 334, Melbourne, Florida 32902, USA ($11·95 plus $3·30 overseas air mail). Note that in an exchange of "Technical Correspondence" (*QST*, July and December 1985,) Walter Maxwell, W2DU rebuts W5QJR's claim that his loop antenna has a gain figure that considerably exceeds that of a dipole; W2DU contends that it would be more correct to claim only that the loop gain *approaches* that of a dipole.

(10) Cap Co Electronics Ltd, Unit 6, Peel Road Industrial Centre, West Pimbo Road, Skelmersdale, Lancs. WN8 9PT.

During the preparation of this article, Cap Co did offer to make a suitable butterfly capacitor available to constructors. ■